Integrated Solid Waste Management

Integrated solid waste management (ISWM) reflects the need to approach solid waste in a comprehensive manner with careful selection and sustained application of appropriate technology, working conditions, and establishment of a ‘social license’ between the community and designated waste management authorities (most commonly local government). ISWM is based on both a high degree of professionalism on behalf of solid waste managers; and on the appreciation of the critical role that the community, employees, and local (and increasingly global) ecosystems have in effective SWM. ISWM should be driven by clear objectives and is based on the hierarchy of waste management: reduce, reuse, recycle — often adding a fourth ‘R’ for recovery. These waste diversion options are then followed by incineration and landfill, or other disposal options. Please refer to Box 3 for a detailed list describing the components of an ISWM Plan.

Components of an Integrated Solid Waste Management Plan

An integrated Solid Waste Management plan should include the following sections:

- All municipal policies, aims, objectives, and initiatives related to waste management;
- The character and scale of the city, natural conditions, climate, development and distribution of population;
- Data on all waste generation, including data covering both recent years and projections over the lifetime of the plan (usually 15-25 years). This should include data on MSW composition and other characteristics, such as moisture content and density (dry weight), present and predicted;
- Identify all proposed options (and combination of options) for waste collection, transportation, treatment, and disposal of the defined types and quantities of solid wastes (this must address options for all types of solid waste arising);
- Evaluation of the Best Practical Environmental Option(s), integrating balanced assessments of all technical, environmental, social, and financial issues;
- The proposed plan, specifying the amount, scale, and distribution of collection, transportation, treatment and disposal systems to be developed, with proposed waste mass flows proposed through each;
- Specifications on the proposed on-going monitoring and controls that will be implemented in conjunction with facilities and practices and ways in which this information will be regularly reported;
- Associated institutional reforms and regulatory arrangements needed to support the plan;
- Financial assessment of the plan, including analysis of both investment and recurrent costs associated with the proposed facilities and services, over the lifetime of the plan (or facilities);
- All the sources of finance and revenues associated with developing and operating the plan including estimated subsidy transfers and user fees;
- The requirements for managing all non-MSW arisings, what facilities are required, who will provide them and the related services, and how such facilities and services will be paid for;
- The proposed implementation plan covering a period of at least 5-10 years, with an immediate action plan detailing actions set out for the first 2-3 years;
- Outline of public consultations carried out during preparation of the plan and proposed in future;
- Outline of the detailed program to be used to site key waste management facilities, e.g. landfills, compost plants, and transfer stations.
- An assessment of GHG emissions and the role of MSW in the city’s overall urban metabolism.
As outlined by the Dutch NGO, WASTE, ISWM is based on four principles: equity for all citizens to have access to waste management systems for public health reasons; effectiveness of the waste management system to safely remove the waste; efficiency to maximize benefits, minimize costs, and optimize the use of resources; and sustainability of the system from a technical, environmental, social (cultural), economic, financial, institutional, and political perspective (van de Klundert and Anschütz 2001).

There are three interdependent and interconnected dimensions of ISWM, which need to be addressed simultaneously when designing a solid waste management system: stakeholders, elements, and aspects. Please refer to Box 4 for further details on the interconnected dimensions of ISWM.

An alternative framework is provided by UN-HABITAT, which identifies three key system elements in ISWM: public health, environmental protection, and resource management (UN-Habitat 2009).

Public Health: In most jurisdictions, public health concerns have been the basis for solid waste management programs, as solid waste management is essential to maintaining public health. Solid waste that is not properly collected and disposed can be a breeding ground for insects, vermin, and scavenging animals, and can thus pass on air- and water-borne diseases. Surveys conducted by UN-Habitat show that in areas where waste is not collected frequently, the incidence of diarrhea is twice as high and acute respiratory infections six times higher than in areas where collection is frequent (UN-Habitat 2009).

Environmental Protection: Poorly collected or improperly disposed of waste can have a detrimental impact on the environment. In low- and middle-income countries, MSW is often dumped in low-lying areas and land adjacent to slums. Lack of enforced regulations enables potentially infectious medical and hazardous waste to be mixed with MSW, which is harmful to waste pickers and the environment. Environmental threats include contamination of groundwater and surface water.
by leachate, as well as air pollution from burning of waste that is not properly collected and disposed.

**Resource Management:** MSW can represent a considerable potential resource. In recent years, the global market for recyclables has increased significantly. The world market for post consumer scrap metal is estimated at 400 million tonnes annually and around 175 million tonnes annually for paper and cardboard (UN-Habitat 2009). This represents a global value of at least $30 billion per year. Recycling, particularly in low- and middle-income countries, occurs through an active, although usually informal, sector. Producing new products with secondary materials can save significant energy. For example, producing aluminum from recycled aluminum requires 95% less energy than producing it from virgin materials. As the cost of virgin materials and their environmental impact increases, the relative value of secondary materials is expected to increase.

**Waste Disposal Options**

The waste management sector follows a generally accepted hierarchy. The earliest known usage of the ‘waste management hierarchy’ appears to be Ontario’s Pollution Probe in the early 1970s. The hierarchy started as the ‘three Rs’ — reduce, reuse, recycle — but now a fourth R is frequently added — recovery. The hierarchy responds to financial, environmental, social and management considerations. The hierarchy also encourages minimization of GHG emissions. See Figure 14 for the waste hierarchy.

*As a minimum, waste should be disposed at a “controlled dump,” which includes site selection, controlled access, and where practical, compaction of waste. Incineration requires a complimentary sanitary landfill, as bottom ash, non-combustibles and by-passed waste needs to be landfilled.
1. **Waste Reduction:** Waste or source reduction initiatives (including prevention, minimization, and reuse) seek to reduce the quantity of waste at generation points by redesigning products or changing patterns of production and consumption. A reduction in waste generation has a two-fold benefit in terms of greenhouse gas emission reductions. First, the emissions associated with material and product manufacture are avoided. The second benefit is eliminating the emissions associated with the avoided waste management activities.

2. **Recycling and Materials Recovery:** The key advantages of recycling and recovery are reduced quantities of disposed waste and the return of materials to the economy. In many developing countries, informal waste pickers at collection points and disposal sites recover a significant portion of discards. In China, for example, about 20% of discards are recovered for recycling, largely attributable to informal waste picking (Hoornweg et al 2005). Related GHG emissions come from the carbon dioxide associated with electricity consumption for the operation of material recovery facilities. Informal recycling by waste pickers will have little GHG emissions, except for processing the materials for sale or reuse, which can be relatively high if improperly burned, e.g. metal recovery from e-waste.

3. **Aerobic Composting and Anaerobic Digestion:** Composting with windrows or enclosed vessels is intended to be an aerobic (with oxygen) operation that avoids the formation of methane associated with anaerobic conditions (without oxygen). When using an anaerobic digestion process, organic waste is treated in an enclosed vessel. Often associated with wastewater treatment facilities, anaerobic digestion will generate methane that can either be flared or used to generate heat and/or electricity. Generally speaking, composting is less complex, more forgiving, and less costly than anaerobic
digestion. Methane is an intended by-product of anaerobic digestion and can be collected and combusted. Experience from many jurisdictions shows that composting source separated organics significantly reduces contamination of the finished compost, rather than processing mixed MSW with front-end or back-end separation.

4. **Incineration:** Incineration of waste (with energy recovery) can reduce the volume of disposed waste by up to 90%. These high volume reductions are seen only in waste streams with very high amounts of packaging materials, paper, cardboard, plastics and horticultural waste. Recovering the energy value embedded in waste prior to final disposal is considered preferable to direct landfiling — assuming pollution control requirements and costs are adequately addressed. Typically, incineration without energy recovery (or non-autogenic combustion, the need to regularly add fuel) is not a preferred option due to costs and pollution. Open-burning of waste is particularly discouraged due to severe air pollution associated with low temperature combustion.

5. **Landfill:** The waste or residue from other processes should be sent to a disposal site. Landfills are a common final disposal site for waste and should be engineered and operated to protect the environment and public health. Landfill gas (LFG), produced from the anaerobic decomposition of organic matter, can be recovered and the methane (about 50% of LFG) burned with or without energy recovery to reduce GHG emissions. Proper landfiling is often lacking, especially in developing countries. Landfiling usually progresses from open-dumping, controlled dumping, controlled landfiling, to sanitary landfiling (see Table 13).

### Waste and Climate Change

GHG emissions from MSW have emerged as a major concern as post-consumer waste is estimated to account for almost 5% (1,460 mtCO₂e) of total global greenhouse gas emissions. Solid waste also includes significant embodied GHG emissions. For example, most of the GHG emissions associated with paper occur before it becomes MSW. Encouraging waste minimization through MSW programs can therefore have significant up-stream GHG minimization benefits.

<table>
<thead>
<tr>
<th></th>
<th>Operation and Engineering Measures</th>
<th>Leachate Management</th>
<th>Landfill Gas Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semi-controlled Dumps</td>
<td>Few controls; some directed placement of waste; informal waste picking; no engineering measures</td>
<td>Unrestricted contaminant release</td>
<td>None</td>
</tr>
<tr>
<td>Controlled Dump</td>
<td>Registration and placement/compaction of waste; surface water monitoring; no engineering measures</td>
<td>Unrestricted contaminant release</td>
<td>None</td>
</tr>
<tr>
<td>Engineered Landfill/Controlled Landfill</td>
<td>Registration and placement/compaction of waste; uses daily cover material; surface and ground water monitoring; infrastructure and liner in place</td>
<td>Containment and some level of leachate treatment; reduced leachate volume through waste cover</td>
<td>Passive ventilation or flaring</td>
</tr>
<tr>
<td>Sanitary Landfill</td>
<td>Registration and placement/compaction of waste; uses daily cover; measures for final top cover and closure; proper siting, infrastructure; liner and leachate treatment in place and post-closure plan.</td>
<td>Containment and leachate treatment (often biological and physico-chemical treatment)</td>
<td>Flaring with or without energy recovery</td>
</tr>
</tbody>
</table>
Methane from landfills represents 12% of total global methane emissions (EPA 2006b). Landfills are responsible for almost half of the methane emissions attributed to the municipal waste sector in 2010 (IPCC 2007). The level of methane from landfills varies by country, depending on waste composition, climatic conditions (ambient temperature, precipitation) and waste disposal practices. Table 14 highlights some examples.

Organic biomass decomposes anaerobically in a sanitary landfill. Landfill gas, a by-product of the anaerobic decomposition is composed of methane (typically about 50%) with the balance being carbon dioxide and other gases. Methane, which has a Global Warming Potential 21 times greater than carbon dioxide, is the second most common greenhouse gas after carbon dioxide.

Greenhouse gas emissions from waste management can readily be reduced. Within the European Union, the rate of GHG emissions from waste has declined from 69 mtCO\textsubscript{2}e per year to 32 million tCO\textsubscript{2}e per year from 1990 to 2007 (ISWA 2009).

**Greenhouse Gas Mitigation Opportunities**

Efforts to reduce emissions from the municipal solid waste sector include generating less waste, improving the efficiency of waste collection, expanding recycling, methane avoidance (aerobic composting, anaerobic digestion with combustion

**TABLE 14**

Landfill Methane Emissions and Total GHG Emissions for Selected Countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Methane Emissions from Post-Consumer Municipal Waste Disposal(\ast) (MtCO\textsubscript{2}e)</th>
<th>Greenhouse Gas Emissions(\ast\ast) (CO\textsubscript{2}, CH\textsubscript{4}, N\textsubscript{2}O) (MtCO\textsubscript{2}e)</th>
<th>% Methane from Disposal Sites Relative to Total GHG Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>16</td>
<td>659</td>
<td>2.4%</td>
</tr>
<tr>
<td>China</td>
<td>45</td>
<td>3,650</td>
<td>1.2%</td>
</tr>
<tr>
<td>India</td>
<td>14</td>
<td>1,210</td>
<td>1.1%</td>
</tr>
<tr>
<td>Mexico</td>
<td>31</td>
<td>383</td>
<td>8.1%</td>
</tr>
<tr>
<td>South Africa</td>
<td>16</td>
<td>380</td>
<td>4.3%</td>
</tr>
</tbody>
</table>

\(\ast\)EPA 2006a.  
\(\ast\ast\)UNFCCC 2005.
of produced methane and capture, treatment and use of landfill gas). Energy generated from methane combustion can displace other fossil fuels either as a process energy resource or as electricity. Suitable technology options by waste management component are provided in Table 15.

### Policy Recommendations for Reducing GHG Emissions

Governments have a range of policy options to encourage waste management practices that will reduce greenhouse gas emissions. Practical approaches that could be applied in most cities include:

- Public education to inform people about their options to reduce waste generation and increase recycling and composting.
- Pricing mechanisms, such as product charges can stimulate consumer behavior to reduce waste generation and increase recycling. A product charge is a cost assessment added to the price of a product and is tied to the cost of the desired waste management system. Consumers would pay for the waste management service when they buy the product. The fees collected would be directed to municipalities relative to the waste generated. An example of this economic mechanism is an excise tax on tires assessed by most states in the US. Product charges are a policy mechanism often better implemented by regional or national governments.
- Another pricing mechanism well suited to urban areas is user charges tied to quantity of waste disposed. Consumers who separate recyclables pay a lower fee for waste disposal. This pricing policy can work well in locations where waste collection is from individual households so that waste quantities for disposal can be readily monitored. However, it may not be practical in many areas in developing countries, particularly in those where there are communal collection points associated with multi-unit households (such as apartment user charges tied to quantity or volume).
- Preferential procurement policies and pricing to stimulate demand for products made with recycled post-consumer waste. Use of compost in public parks and other property owned by cities.